Bulletin 550 May, 1950

Spraying Tomato Foliage with Sucrose to Increase Carbohydrates and Protect Against Injury by Urea Sprays

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In using urea sprays to increase nitrogen levels in tomatoes grown under glass, it was found that the recommended 5 pounds per 100 gallons of water caused burning, especially during short winter days.

Apparently, high concentrations of carbohydrates must be present in the leaf tissues to combine with the urea as it enters the tissue if burning is to be prevented. Since tomatoes do not maintain the carbohydrates necessary for this, spraying with sucrose in the urea solutions was tried. It was hoped that the leaves would absorb the sucrose and increase yields of fruits, especially during short days of winter when carbohydrate manufacture is at a minimum in the tomato plant.

Method

Large potted plants were selected for the tests. First a solution containing 0.1 M urea and 0.1 M sucrose was tried. Variations from these concentrations up to 1 M urea and 1 M sucrose also were used. Five pounds of urea per 100 gallons of water is approximately a 0.1 molar (M) solution. The effects of these varying mixtures were determined by the marginal burning evident in 1 to 2 days after application and also by making carbohydrate tests of the extracted cell sap of petioles, leaves, and extractions of the ripe fruit.

The carbohydrate tests were made by the carbonization method.[1] This does not distinguish between kinds of carbon compounds, but gives a good indication of total carbohydrates present, and is rapid, enabling many determinations to be made. The duplicates were quite uniform, indicating that the tests were reliable. Nitrogen levels were determined by the rapid soluble nitrogen test.[2] Tests on pure urea solutions indicated that all the nitrogen in urea is determined by this method. The test, therefore, included any uncombined urea, nitrates, and amino acids in the plant extracts.

[1] E. M. Emmert and C. S. Waltman, "A Rapid Method for Estimating Carbon Contained in Plant Tissue Extracts," Amer. Soc. Hort. Sci. Proc. 41:245-50, 1942.

[2] E. M. Emmert, *Plant Tissue Tests as a Guide to Fertilizer Treatment of Tomatoes.* Ky. Agr. Expt. Sta. Bul. 430, 1942.

Mature lower petioles were extracted by crushing 1 gm with 10 cc of 2-percent acetic acid and 0.5 gm charcoal and filtering. Leaf tissues were extracted in the same way. Ten gm of a cross section of the fruits were crushed with 1 gm of charcoal and 20 cc of 2-percent acetic acid and filtered. One cubic centimeter of this extract was diluted to 25 cc and 1 cc of this used for the carbohydrate test.

Tests for Prevention of Marginal Burning from Urea Sprays

In the first trials, 0.1 M (about 30 lb to 100 gallons) sucrose was mixed with 0.1 M urea. Large potted plants sprayed with this mixture at no time showed any burning. Then a spray of 0.5 urea (25 lb to 100 gallons) mixed with 0.5 M sucrose (about 150 lb per 100 gallons) was used. No burning resulted. The 0.1 M urea alone caused slight burning and 0.5 M urea alone burned so severely that the plants were permanently injured.

Then a series of tests were set up where 1 M urea was mixed with 1 M sucrose, 0.5 molar sucrose 0.25 M sucrose and 0.1 M sucrose. Even the 1 M urea (50 lb of urea to 100 gallons) did not burn when mixed with 1 M sucrose. With 0.5 M sucrose there was some burning and with 0.25 and 0.1 M sucrose the burning was severe.

A test was made 0.5 M urea with 0.25 M sucrose and there was some burning. Then a 0.3 M sucrose was tried with 0.5 M urea and no burning occurred. This shows that there is a definite point at which the protection afforded by sucrose stops. In order to be safe 0.5 M sucrose was used with 0.5 M urea on large plants in a main experiment in which yields are to be taken. No burning has been found on the vigorously growing large plants in beds when 25 lb to 100 gallons of urea was used with 0.5 M sucrose.

Since these preliminary trials looked promising, a more detailed study on the use of sucrose as a protectant against urea burning was made.

The following treatments were sprayed on single, potted tomatoes on January 24, 1950, and repeated on January 26. Notes on burning or lack of burning were taken on February 2, 1950.

	Degree of Burning
1.0 M Urea + 1.0 M Sucrose	None
1.0 M Urea + 0.5 M Sucrose	Marginal burning
0.5 M Urea + 1.0 M Sucrose	None
0.5 M Urea + 0.5 M Sucrose	None
0.5 M Urea + 0.1 M Sucrose	Marginal burning
0.5 M Urea + 0.05 M Sucrose	Badly burned
0.5 M Urea + 0.01 M Sucrose	Badly burned

0.3 M Urea + 1.0 M Sucrose	None
0.3 M Urea + 0.5 M Sucrose	None
0.3 M Urea + 0.10 M Sucrose	Marginal burning
0.3 M Urea + 0.05 M Sucrose	Badly burned
0.3 M Urea + 0.01 M Sucrose	Badly burned
0.2 M Urea + 1.0 M Sucrose	None
0.2 M Urea + 0.5 M Sucrose	None
0.2 M Urea + 0.1 M Sucrose	None
0.2 M Urea + 0.05 M Sucrose	Marginal burning
0.2 M Urea + 0.01 M Sucrose	Marginal burning
0.1 M Urea only	Marginal burning

Carbon and Nitrogen Concentrations Found in Leaves and Fruits

A preliminary test was made on washed leaves of plants grown in sand cultures:

Treatment	*Carbon in leaves ppm*	*Carbon in fruits ppm*
1. 0.5 M Urea + 0.5 M Sucrose	178	3360
2. 0.5 M Urea + 0.5 M Sucrose, Nitrogen to roots	86	770
3. No Urea or Sucrose, Nitrogen to roots	37	588
4. No Urea or Sucrose, Nitrogen to roots	36	330

Part of the high content of carbon in No. 1 undoubtedly was due to stunting from lack of nitrogen application to the roots. This was not true in No. 2, hence the higher content of carbon found in treatment No. 2 in comparison to treatments 3 and 4 must have been due to sucrose additions.

A test was then made on fruits from these plants as described previously.

At least a part of the high content of carbon in No. 1 likely was due to sucrose spraying even if the plants were stunted. In No. 2 it was almost certain that sucrose spraying caused the increase. The high-carbon tomatoes were especially sweet, well filled, with few seeds. The outside appearance was also good. The taste was exceptionally good.

In order to be more certain of the sucrose uptake, plants set in soil ground beds were sprayed with urea and sucrose just as the first cluster was beginning to show flowers. Leaf analyses gave these results:

Time and treatment	*Carbon ppm*
Day after spraying (cloudy)	
0.5 M sucrose + 0.5 M urea	44.2
No sucrose or urea	20.7
3 days after spraying (bright sun)	
0.5 M sucrose only	53
0.5 M sucrose + 0.5 M urea	40
No sucrose or urea	28

It should be noted that these leaves were washed thoroughly in hot water so that unabsorbed sucrose on the surface would not enter into the test.

In order to test the effect of nitrogen as well as sucrose spraying on carbon content, a more detailed test was made with the following results:

Treatment	*Carbon, ppm*	*Nitrogen, ppm*
0.5 M sucrose only	29	847
0.5 M sucrose only	26	1257
0.5 M sucrose + 0.5 M urea	35	871
0.5 M sucrose + 0.5 M urea	38	1147
0.25 M urea + 0.25 M sucrose	19	1142
0.25 M sucrose + 0.25 M urea	13	1285
Check	24	714
Check	8	1247

The carbon varied well with sucrose treatments, but it should be noted that nitrogen concentration also influenced the carbon content. The higher the nitrogen the lower the carbon in all comparisons. The low nitrogen in the check especially caused a high carbon concentration as compared to the high nitrogen check.

Summary

Equal molar solutions of sucrose mixed with urea solutions stopped urea burning in all cases and enabled ten times as much urea to be used on tomatoes without burning as when no sucrose was used; namely, 50 lb instead of 5 pounds to 100 gallons.

Sucrose spraying increased the sucrose in the extracts of both leaves and fruits. Quality and taste of the fruits on the sucrose-sprayed plants were much better.

The effect of sucrose spraying on yields is yet to be determined.

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